AS/A Level GCE

Practical Skills Handbook

GCE Chemistry A

OCR Advanced Subsidiary GCE in Chemistry A H034

OCR Advanced GCE in Chemistry A H434

This Practical Skills Handbook is designed to accompany the OCR Advanced Subsidiary GCE and Advanced GCE specifications in Chemistry A for teaching from September 2008.

OCR will update this document on a regular basis. Please check the OCR website (www.ocr.org.uk) at the start of the academic year to ensure that you are using the latest version.

Version 1.6
The only changes made between version 1.5 and 1.6 are
- Clarification that the mark scheme release date is 1 December of each year.
- Revised information regarding availability of INSET materials.
- Update to CLEAPSS website URL.

Version 1.5
The only changes made between version 1.4 and 1.5 are
1. the addition of information about the mark schemes being released on Dec 1st.
2. Helpful guide to Practical Skills addition to assist with clarification of graphical skills.
3. Appendix 1 – Measurements has moved into Section 10 Helpful guide to Practical Skills.
4. Appendix 2 – Interchange Help Sheet has moved to Section 9

Version 1.4
The only changes made between version 1.3 and version 1.4 are:
- An update to Health and Safety information in Section 8.
- Information on recording volumes during titrations and mean titres in Appendix 1.

Version 1.3
The only changes made between version 1.2 and 1.3 were the incorporation of updated screenshots on pp. 9 and 10, the inclusion of an Interchange Help Sheet as an Appendix and the removal of FAQs, which are now available as a separate document. No other changes were made.

Contents

1 Introduction

New GCE A/AS specifications in Chemistry have been introduced for teaching from September 2008. The new specifications are set out as units, subdivided into teaching modules. Each teaching unit is assessed by its associated unit of assessment. Guidance notes are provided within specifications to assist teachers in understanding the requirements of each unit.

This Handbook plays a secondary role to the Specification itself. The specification is the document on which assessment is based and this Handbook is intended to elaborate on the content of the specification to clarify how skills are assessed and what practical experience is necessary to support an assessment. The Practical Skills Handbook should therefore be read in conjunction with the Specification.

During their study of Chemistry, candidates are expected to acquire experience of planning, carrying-out, interpreting, analysing and evaluating experiments and it is important to recognise that these aspects of practical work require both teaching and continuing practice. Experience has shown that evaluating experiments and suggesting improvements to the procedures employed is a difficult skill for candidates to master.

Planning skills will **not** be directly examined as part of the centre-based assessment but may be tested within the theory papers at both AS and A2 levels. Other skills will be internally assessed by the centre using the scheme shown on the next page.

2 The assessment model

Summary of the model

Practical and investigative skills developed within contexts encountered during Advanced Subsidiary GCE Chemistry (for Unit F323) or Advanced GCE Chemistry (for Unit F326) are assessed by means of three types of task (Qualitative, Quantitative and Evaluative) at each level.

Thus, candidates are required to carry out **three** tasks at AS and **three** tasks at A2:

1. Qualitative task [10 marks]
2. Quantitative task [15 marks]
3. Evaluative task [15 marks]

Tasks will be chosen from a selection provided by OCR *via* the secure Interchange website. Initially, a choice of three Tasks will be offered for each type. All Tasks will be refreshed or replaced each year and additional tasks may be made available. Tasks will be available until 15 May in each year. Tasks for the following year will be available from early June, with mark schemes becoming available on 1 December each year.

The Qualitative and Quantitative tasks will test skills of observation, recording and reaching valid conclusions.

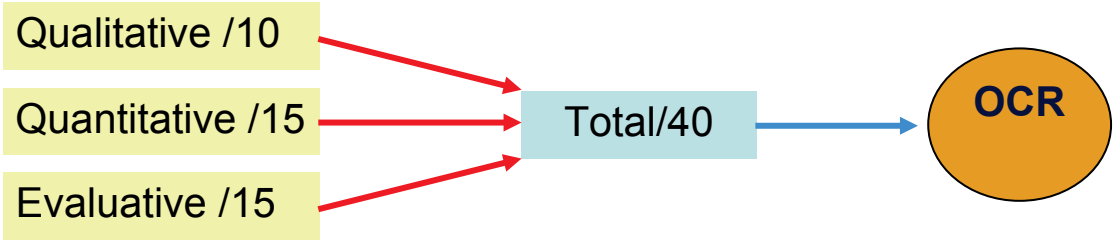
The Evaluative task will test the ability to analyse and evaluate the procedures followed and/or the measurements made. Candidates may also be asked to suggest simple improvements that would increase the reliability or accuracy of an experiment. The Evaluative task may be linked to either a Qualitative or a Quantitative experiment but no further data collection will be required. Any additional data required will be supplied within the Evaluative task.

Candidates carry out all of their assessed tasks under direct teacher supervision.

Each task is internally assessed using a mark scheme provided by OCR *via* the Interchange website.

Candidates may attempt more than one task from each task type with the best mark from each type being used to make up the overall mark. A candidate is only permitted one attempt at each task.

For each candidate, centres will supply OCR with a single mark out of 40.
Each practical skills unit is teacher assessed and externally moderated by OCR.
Although practical tasks can be used throughout the year, entry for the AS and the A2 practical skills units is available only in the June session of each year.



The mark schemes supplied by OCR will be based on the following criteria:

	Assessable learning outcomes
1. Qualitative Task • Candidates carry out a practical task using instructions supplied by OCR.	Candidates should be able to: (a) demonstrate skilful and safe practical techniques using suitable qualitative methods; (b) make and record valid observations and organise results suitably.
2. Quantitative Task • Candidates carry out a practical task using instructions supplied by OCR.	Candidates should be able to: (a) demonstrate skilful and safe practical techniques using suitable quantitative methods; (b) make and record accurate measurements to an appropriate precision; (c) analyse, interpret and evaluate experimentally derived results quantitatively to reach valid conclusions.
3. Evaluative Task • This task may extend one of the qualitative or quantitative tasks. • Candidates will evaluate the quality of the data and procedures. • Evaluative tasks will **not** require additional data collection.	Candidates should be able to: (a) analyse and interpret data, identify anomalies and reach valid conclusions; (b) assess the reliability and accuracy of an experimental task; identify significant weaknesses in experimental procedures and measurements; (c) understand and propose simple improvements to experimental procedures and measurements.

The assessment of practical skills will include the following qualities which will need to be developed before candidates carry out the practical tasks.

	Quality A1	Quality A2
Strand A	Demonstrate skilful and safe practical techniques using suitable qualitative methods.	Demonstrate skilful and safe practical techniques using suitable quantitative methods.

	Quality B1	Quality B2
Strand B	Make and record valid observations; organise results suitably.	Make and record accurate measurements to an appropriate precision.

	Quality C1	Quality C2
Strand C	Recognise and interpret data, identify anomalies and reach valid conclusions.	Analyse, interpret and evaluate experimentally derived results quantitatively to reach valid conclusions.
	Quality C3	**Quality C4**
	Assess the reliability and accuracy of an experimental task; Identify significant weaknesses in experimental procedures and measurements.	Understand and select simple improvements to the experimental procedures and measurements.

The qualities assessed by each task type, Qualitative, Quantitative and Evaluative, are shown below.

F323: AS Task Types

Task type	Quality								Assessment outcome			Total
	A1	A2	B1	B2	C1	C2	C3	C4	AO1	AO2	AO3	
Qualitative	✓		✓								10	10
Quantitative		✓		✓		✓			3	2	10	15
Evaluative					✓		✓	✓	3	2	10	15
TOTAL												**40**

F326: A2 Task Types

Task type	Quality								Assessment outcome			Total
	A1	A2	B1	B2	C1	C2	C3	C4	AO1	AO2	AO3	
Qualitative	✓		✓								10	10
Quantitative		✓		✓		✓			2	3	10	15
Evaluative					✓		✓	✓	2	3	10	15
TOTAL												**40**

Downloading Practical Skills tasks

Tasks, Mark Schemes, and Instructions for Teachers and Technicians are provided to centres (as separate PDF files combined into one zip file) via OCR's secure website, Interchange (https://interchange.ocr.org.uk).

Copies of the *Chemistry A Data Sheet*, the Practical Skills Handbook and coursework forms are also available via Interchange and via OCR's public website (www.ocr.org.uk).

(PDF files require the use of adobe acrobat reader. Free copies of acrobat reader are available from https://get.adobe.com/uk/reader; If you use Windows 95, 98, ME, or NT, a zip program such as WinZip or PKZip can be used to extract the files. Windows XP has a built-in zip extractor.)

How to use OCR Interchange

OCR Interchange is a secure extranet enabling registered users to administer qualifications on-line. Your Examinations Officer is probably using OCR Interchange to administer qualifications already. If this is not the case, then your centre will need to register.

Your Examinations Officer will be able to:

- download the relevant documents for you by adding the role of 'Science Coordinator' to their other roles or
- make you a New User (Science Coordinator role) so that you can access the GCE Chemistry A pages and download documents when you need them.

The website address for Interchange is:

https://interchange.ocr.org.uk

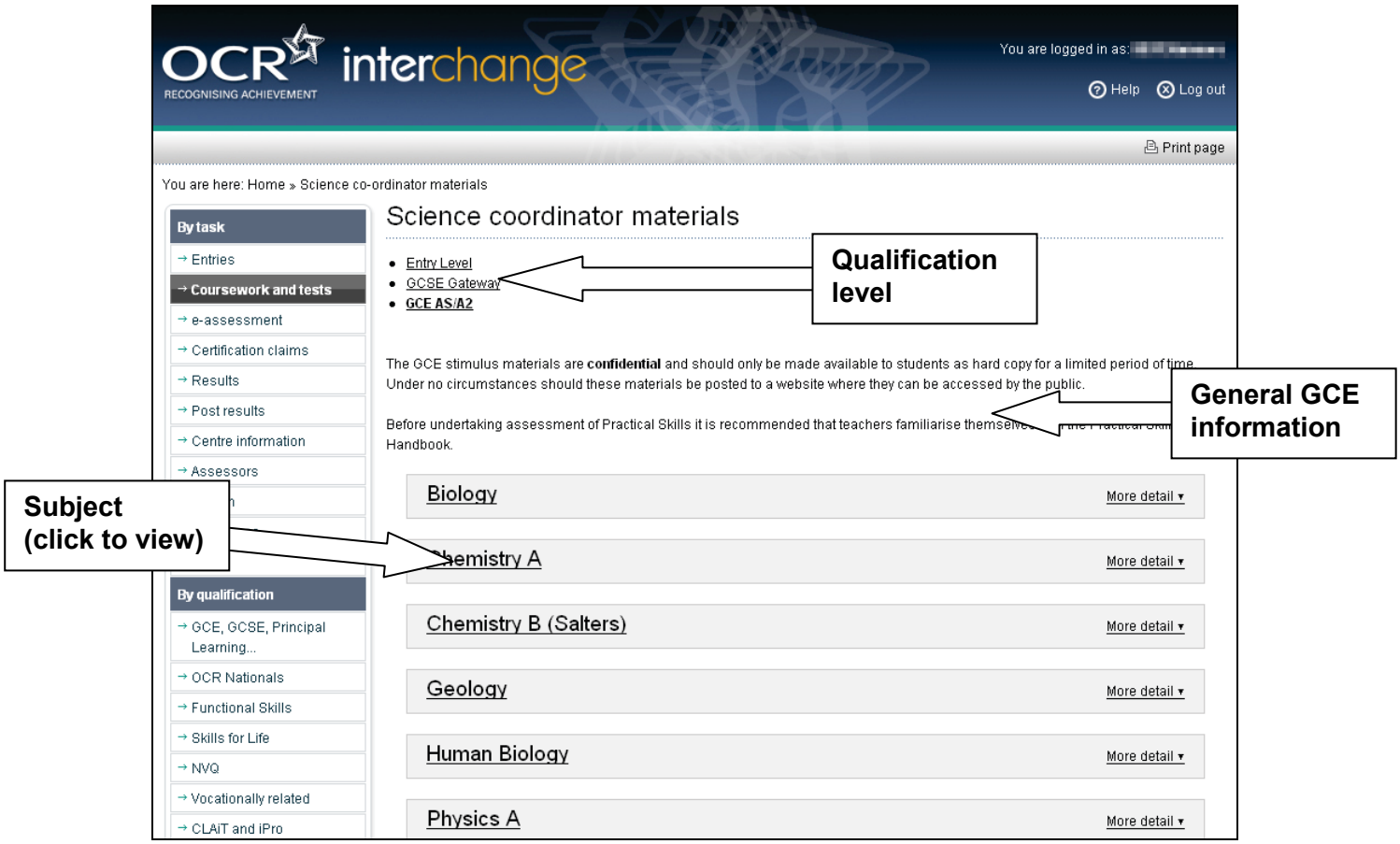
The teacher who has downloaded these materials is responsible for ensuring that they are stored securely so that candidates do not have the opportunity to access them. A record should be kept of the dates on which materials are downloaded.

Distribution of the Practical Tasks is limited to those candidates who are currently undertaking that Task. Task sheets should be photocopied and issued to candidates at the start of the Task. They must be counted out and in; numbering the documents may help to keep track of them.
All unused Tasks and candidates' scripts must be collected after the assessment and stored securely or destroyed.

Candidates must not take Tasks out of the room where assessments are taking place.

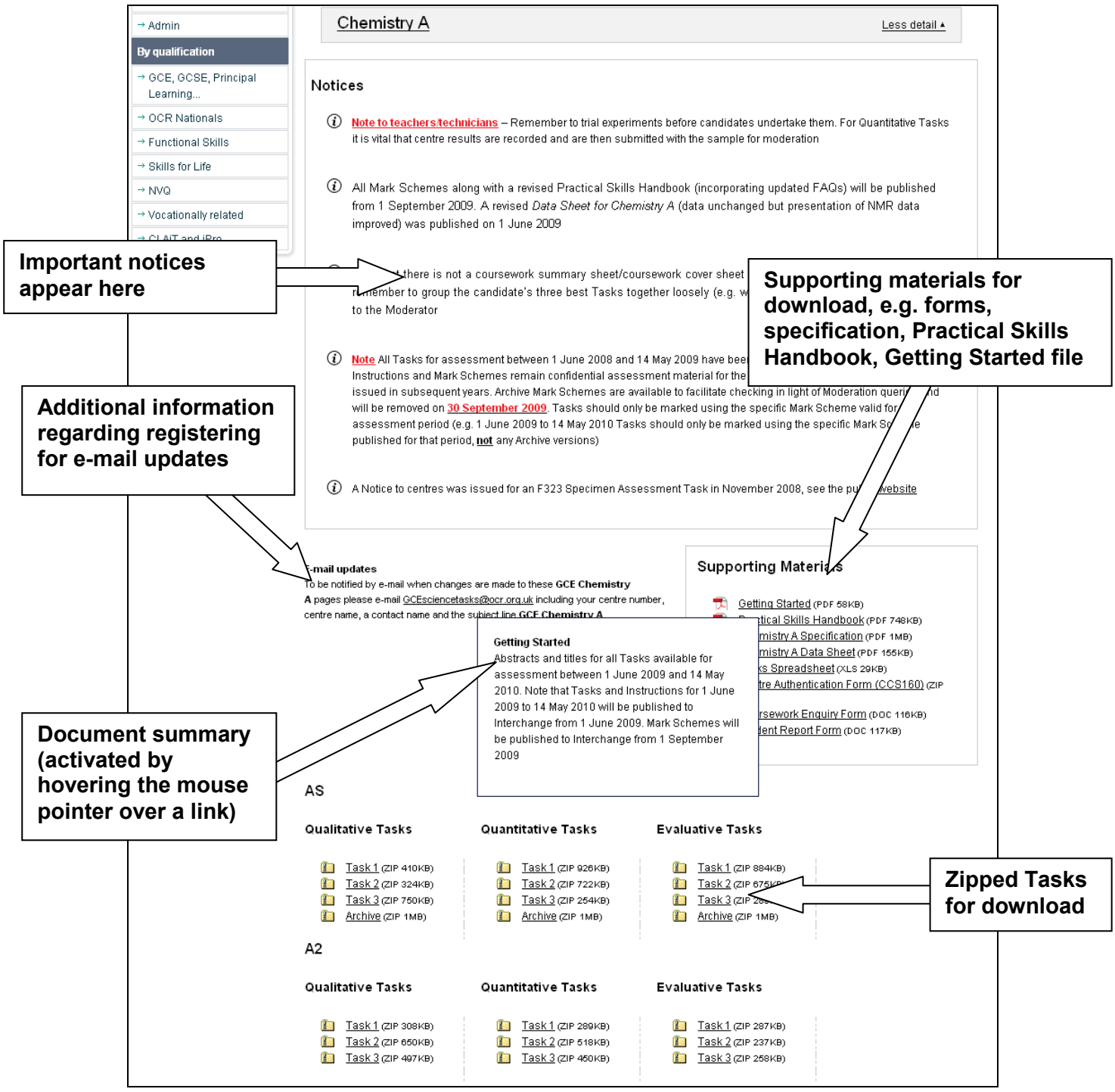
Under no circumstances can candidates be allowed to see the mark schemes.

Science Materials pages are arranged according to qualification level and subject (see below).



The user simply clicks on the relevant link to access the relevant subject material. Any important notices are shown at the top of the page along with useful supporting materials (e.g. the specification, the Practical Skills Handbook, forms) and a 'Getting started' file (which includes an Abstract and title for each assessment task for the current assessment year). Tasks are arranged according to level and type (Qualitative, Quantitative and Evaluative, see below). Hovering the mouse pointer over a Task or document link generates a summary of the file.

Simply clicking on the Task link allows you to download the zipped material to your desktop. The zip file contains everything you need to complete the task (instructions and task). All files have a unique name so there is no danger of overwriting material on your computer.



E-mail updates

To be notified by e-mail when changes are made to the **GCE Chemistry A** page on Interchange please e-mail GCEsciencetasks@ocr.org.uk including your centre number, a contact name and the subject line **GCE Chemistry A**. It is strongly recommended that all centres register for e-mail updates.

Registering for Interchange

If your Examinations Officer is not already a registered user of Interchange then he/she will need to register before the Chemistry A Tasks can be downloaded.

This is a straightforward process:

- Go to the website – https://interchange.ocr.org.uk ;
- The first page has a New User section;
- Click on Sign Up to access the OCR Interchange Agreement Form 1;
- Download this document and fill in your details;
- Return form by post to OCR Customer Contact Centre, Westwood Way, Coventry, CV4 8JQ or fax the form back to 024 76 851633;
- OCR will then contact the Head of Centre with the details needed for the Examinations Officer to access OCR Interchange.

Also see Section 9 – Interchange Help Sheet

Availability of Tasks

Tasks and Instructions for Teachers and Technicians will be available until **15 May** in each year. Tasks for the following year will be available from early June. Mark schemes will be released on 1 December each year.

It is intended that Tasks should form part of the normal teaching programme and so may be taken by candidates at any time during the year. Where possible, a Task should be administered immediately after the knowledge, understanding and skills required for the Task have been taught.

Level	Unit & Task	First Tasks on Interchange by	Coursework submission date
AS	F323 Qualitative (×3) Quantitative (×3) Evaluative (×3)	June 2008	15 May each year from 2009
A2	F326 Qualitative (×3) Quantitative (×3) Evaluative (×3)	June 2009	15 May each year from 2010

Security

It is the responsibility of the centre to ensure that downloaded Tasks, mark schemes, instructions (including any copies made of these documents), and candidates' scripts are stored securely. Any breach in security must be reported to OCR as soon as possible by submitting a written report (a blank report form is available on Interchange) from the Head of Centre to the Subject Officer detailing the circumstances, the candidates concerned and any action taken.

The instructions for each assessed Task contain information to allow teachers to check the availability of the necessary apparatus and chemicals and for any solutions to be prepared in advance.

Tasks, mark schemes and Instructions can be downloaded at any time as long as they are kept secure. The instructions summarise the information that may be given to candidates regarding assessed Tasks; no other information must be given either directly or indirectly to candidates relating to the content of the Tasks or the marking.

Candidates' scripts for all completed Tasks must be stored securely and they should be available for moderation. Centres should retain Tasks securely until such time as they are clear that candidates will not wish to re-submit work to OCR in future sessions. At this point the work should be securely destroyed.

In order to ensure consistency across each year of the specification, the old Tasks cannot be used for practice. It is also possible that there will be a legacy opportunity for this unit, which also means that Tasks should remain confidential.

How to use the Tasks

There are at least three Tasks available of each type: Quantitative, Qualitative and Evaluative. These may be used in a variety of ways. For example, candidates may complete all three of the Quantitative Tasks and the teacher can then submit the best mark. Alternatively, the teacher may use the first Task for formative assessment, the second for submission of marks and keep the third in reserve in case a particular candidate does not perform well on the second Task.

A candidate is not permitted to have more than one attempt at a single Task, or to re-write or change a Task once it has been submitted to the teacher for marking.

The experiments

The experiments used in the Tasks have been trialled. The Instructions provided should ensure that the candidates are able to collect appropriate data in the time available. However, it is vital that the teacher trials the Tasks before they are attempted by the candidates to ensure that:

- appropriate materials and equipment are available;
- the experiment works and generates the expected data.

On some occasions it may be necessary to provide a data set against which candidates' results can be compared. In such cases this requirement will be stated in the Instructions for Teachers and Technicians.

Teachers may make appropriate changes to the materials and apparatus listed in the Instructions where these make provision easier/cheaper and they have no impact on the outcome, or demand, of the experiment. Other changes can be made to, for example, volumes/concentrations/amounts in order to make the experiment work as intended and to ensure that candidates are able to make appropriate observations/measurements. **All such changes may be made without OCR's approval**, but details must be retained and made available to the Moderator when work is submitted.

Details of changes made must be notified to OCR by e-mail to **GCEsciencetasks@ocr.org.uk**. Remember to include the centre number on all e-mails.

We will acknowledge all e-mails but will only respond in detail where there are concerns over suggested modifications. OCR may update the materials on the Interchange website where this is appropriate. If there are any issues with any of the experiments **that cannot be satisfactorily resolved by the centre**, details should be provided to OCR using the same e-mail address.

Centres with more than one teaching group

It is recognised that some centres are likely to have more than one group with lessons timetabled at different times. In these circumstances, centres are asked to ensure that a particular Task is carried out by all the groups in as short a period as possible.

Absence at the time of an assessment

If a candidate is absent from a centre when an assessment is carried out, the Task may be set at an alternative time provided that the centre is satisfied that security has been maintained by keeping all materials secure.

Candidates with access arrangements

Candidates who are eligible for access arrangements and need additional time for the Evaluative Task may be given up to 25% extra time and their name should be recorded on the Interchange Access Arrangements site. Where other access arrangements are required, applications should be made to OCR at the beginning of the course using the standard forms and procedures in the Joint Council regulations and guidance document. However, it should be remembered that these Tasks are intended to assess practical skills. Credit is given to those skills which the candidate has performed independently. The Disability Discrimination Act lays no duty on awarding bodies to make reasonable adjustments with respect to the application of a competence standard or, in this case, the assessment objective being tested.

Unexpected circumstances

If an unexpected problem (such as a fire alarm or other circumstance beyond the teacher's control) occurs while an assessed practical Task is taking place, the Task may be resumed subsequently provided the teacher ensures that no candidate is likely to have been advantaged or disadvantaged by doing so.

Support allowed for candidates

All practical Tasks will be accompanied by appropriate instructions. Teachers may provide additional safety instructions (including written advice) if this is felt to be necessary.

Candidates will not be permitted to refer to their class notes or to books during the Task except where specifically indicated on the Task cover sheet and Instructions. Use of the *Chemistry A Data Sheet* (available from Interchange and *www.ocr.org.uk*) is allowed.

If it becomes necessary for a teacher to provide a candidate with assistance during the course of a practical Task, the work may still be marked alongside the work of other candidates but the Task sheet must be annotated to indicate the assistance given. The teacher should use their professional judgement to award marks appropriately.

Supervision

All Tasks must be carried out under the direct supervision of the teacher. However, they are not practical examinations and there is no requirement for 'examination conditions' to be imposed. Candidates may need to interact as they collect materials or use particular pieces of apparatus, but the teacher should set up the Tasks so that this interaction is kept to a minimum. The teacher must ensure that candidates do not copy from, or assist, each other so that s/he can with confidence authenticate the work of each candidate.

Authentication

It is the responsibility of the centre to ensure that the work submitted for assessment is that of the candidate involved.

Group work

Candidates must work individually to collect their own data. However, where a Task requires the collection of a large data set, instructions may include the pooling of data from a number of candidates and each candidate will then work with the same large data set. It will always be expected that each candidate contributes his/her data to the pool. In some cases candidates may need to share equipment or apparatus and the centre must make arrangements for this to take place without disadvantaging any candidates.

Time allowed for Tasks

Quantitative and Qualitative Tasks are not time restricted: most have been designed to be conducted in a single practical session lasting about an hour. However, there may be a number of circumstances in which it is not possible to complete the work in the time available; for example, there may be difficulties with the experiment, a fire alarm or a shortage of equipment. In such cases, candidates' work should be collected in and issued to them again at the start of the next lesson. They must **not** take the work away with them or complete it without supervision.

Evaluative Tasks should be completed within 1 hour.

Some Qualitative and Quantitative Tasks may require the use of two practical sessions. Where this is the case, the Task may be divided to allow a convenient point at which the experiment can be set aside for completion in the second session. In such cases the candidate Task sheets may be provided in two sections.

Submission date for work

Candidates' marks must be despatched to the Moderator and to OCR to arrive by 15 May in the year of the examination.

The following forms must be included with the submitted marks:

- Centre authentication sheet (CCS160) (available from www.ocr.org.uk);
- Details of any changes made to the experiments. (Changes can be marked up on a blank copy of the Task or Instruction sheet). Please attach a copy of any correspondence with OCR;

An interactive Marks Spreadsheet is also available on Interchange for recording marks; if this is used it will help the Moderator if a copy is included with the submitted marks.

The Moderator will ask for a sample of work. If there are ten or fewer candidates at the centre, all work submitted should be sent to the Moderator to arrive by 15 May.

Internal standardisation

A centre must set up an internal standardisation procedure to ensure that all teachers at the centre are applying the mark schemes in the same way. This procedure could include double marking of a sample of candidates, or the remarking of work by a senior member of staff.

Coursework consultancy

OCR offers a coursework consultancy service whereby centres can send up to four photocopies of marked work to OCR for commentary by a senior Moderator. If a centre wishes to make use of this service, work should be submitted to OCR no less than 8 weeks before the coursework submission date (15 May). The coursework enquiry form is available at www.ocr.org.uk and on Interchange.

Repeating Tasks

Candidates can only attempt a Task once. However, if they score poorly on a Task they may take another Task from within that Task-type.

Marking advice for teachers

The marking schemes provided to centres have been made as explicit and as easy to apply as possible. Teachers should note that the mark schemes are not hierarchical. A measure of professional judgement may sometimes be necessary.

Once the work has been collected in, it must be marked by the teacher as it stands. **Under no circumstances can a candidate be allowed to change or elaborate on an answer.**

Teachers are reminded that it is possible for a candidate to be assessed on another occasion using a different Task and that the best mark achieved for each Task type should be submitted. It is appropriate for the teacher to provide feedback to explain how the work could have been improved although details of the mark scheme must not be directly communicated to the candidate.

Tasks should be marked clearly, in red ink, and in accordance with the Task-specific mark scheme. Annotation can help the Moderator and staff in the centre who are checking the marking as part of internal standardisation.

Useful annotations consist of:

- ticks and crosses against responses to show where marks have been earned or not earned;
- specific words or phrases to confirm why a mark has been earned or indicate why a mark has not been earned (e.g. indicate an omission).

Where a candidate has given an answer not covered by the mark scheme, the teacher should use his/her professional judgement to decide whether the answer is worthy of credit. If it is, then the script should be annotated accordingly and the mark(s) awarded.

3 General requirements for AS and A2 practical work

Suggested practical activities have been included within the specification at the end of each module. Whilst carrying out these practice experiments during the course is not a requirement, their purpose is to ensure that the skills required for assessment will have been covered. Alternative experiments may be chosen but centres should be careful to consider whether sufficient experience will have been provided for candidates prior to the use of the assessed Tasks.

Skill development

There are generic skills which should be developed during the study of AS and A2 Chemistry. The sophistication required of candidates should increase throughout the course, partly as their practical experience grows but also through the extra demands expected by more complex experiments.

General

At both levels, the course aims to provide candidates with the opportunity to:

- develop good laboratory technique;
- make and record accurate measurements and observations;
- interpret the results of experiments to form theories or conclusions;
- establish whether data collected from experiments is valid and reliable;
- evaluate experimental technique and scientific method in light of practical experience;
- gain a knowledge of laboratory safety and the safe use of chemicals;
- learn the importance of careful waste chemical disposal and the potentially harmful effects of chemicals on the environment.

In teaching, teachers should focus on the key areas above whilst developing the candidates' skills through a coherent practical programme.

In carrying out practical Tasks, candidates should acquire the necessary experience to be able to carry out the Qualitative, Quantitative and Evaluative Tasks that will be tested by the assessed Tasks.

Qualitative Tasks

Candidates should be able to:

- identify any hazards in the chemicals to be used or made, noting down appropriate control measures (e.g. fume cupboard, eye protection, protective gloves, extinguishing naked flames);
- handle safely flammable, corrosive, toxic and harmful materials, including solids, liquids and gases;
- use appropriate techniques, reagents and apparatus to complete suitable activities;
- manipulate standard laboratory apparatus safely and with confidence to produce accurate data;

- record all suitable observations and data in an appropriate format and to an appropriate degree of accuracy, taking into consideration the apparatus used;
- use and record the correct units for all measurements taken;
- provide simple conclusions based on the observations made.

Quantitative Tasks

Candidates should be able to:

- carry out quantitative experiments with appropriate care and precision;
- make and record measurements reliably and accurately;
- perform calculations, based on their practical work;
- use units accurately;
- use appropriate numbers of significant figures consistent with their least accurate measurement;
- construct and interpret appropriate graphs from data collected or provided;
- reach a valid conclusion based upon the data obtained from experiments.

Evaluative Tasks

Candidates should be able to:

- recognise anomalous results on the basis of measurements taken or provided;
- identify the limitations of accuracy in experimental procedures;
- recognise that some errors may be inherent in the apparatus used;
- calculate percentage errors involved in measurements taken using:

  (i) volumetric flasks, pipettes and burettes,
  (ii) measuring cylinders, thermometers and balances;

- evaluate both the procedural and measurement errors associated with a particular experiment and comment on the most significant errors;
- suggest sensible improvements to experimental procedures and the taking of measurements based on their laboratory experience

4 Practical work for AS Unit F323

This section provides a summary of the practical experience and skills that will be acquired by the use of the experiments suggested in the modules or by the use of equivalent Tasks devised by the centre.

F321 Atoms, Bonds and Groups

(a) Volumetric analysis techniques to include:
- **(i)** use and preparation of a pipette to measure accurately a fixed volume of solution;
- **(ii)** use and preparation of a burette to deliver accurately a measured volume of solution;
- **(iii)** the dilution of solutions using volumetric apparatus;
- **(iv)** the preparation of a standard solution from both solids and liquids;
- **(v)** titration to an appropriate degree of accuracy.

(b) A quantitative procedure to measure the volume of an evolved gas, collected either by up-turned measuring cylinder or gas syringe.

(c) The determination of the percentage of water of crystallisation and the number of molecules of water of crystallisation in a hydrated salt.

(d) The preparation of salts from acids and bases.

(e) Simple test-tube reactions involving the following:
- **(i)** dilute acids on metals, bases, alkalis and carbonates;
- **(ii)** the thermal decomposition of some group carbonates;
- **(iii)** the identification of halides in solution;
- **(iv)** halogen displacement reactions;
- **(v)** the formation of precipitates.

F322 Chains, Energy and Resources

(a) Organic experiments exemplified by:
- **(i)** the preparation of ethanal from ethanol by oxidation with acidified dichromate;
- **(ii)** the preparation of an organic liquid such as cyclohexene by dehydration of cyclohexanol or 1-bromobutane from butan-1-ol;
- **(iii)** the reaction of alkenes with bromine water;
- **(iv)** the reactions of primary, secondary and tertiary alcohols with acidified dichromate to show oxidation;
- **(v)** the use of mass spectra and infrared data to establish the molecular mass of a compound and its functional groups.

(b) Enthalpy experiments involving both direct and indirect determination of an enthalpy change of a reaction (such as the decomposition of calcium carbonate).

(c) The production of a volume–time graph from a simple rate experiment.

(d) Simple test-tube experiments to illustrate the effect of a change in concentration or temperature on the position of equilibrium.

5 Practical work for A2 Unit F326

This section provides a summary of the practical experience and skills that will be acquired by the use of the experiments suggested in the modules or by the use of equivalent Tasks devised by the centre.

It should be noted that the practical experience acquired at AS may be tested at A2.

F324 Rings, Polymers and Analysis

(a) The preparation and purification of a solid organic compound and the measurement of its melting point as a test for purity.

(b) The preparation of an organic liquid compound (e.g. the preparation of an ester). It is also expected that candidates will be aware of the procedures involved in the purification and re-distillation at an appropriate temperature of the product obtained.

(c) Qualitative tests to distinguish between:

- **(i)** saturated and unsaturated compounds using bromine water;
- **(ii)** primary and tertiary alcohols using acidified potassium dichromate;
- **(iii)** phenols and aliphatic alcohols using bromine;
- **(iv)** carbonyl and other functional groups using 2,4-dinitrophenylhydrazine;
- **(v)** aldehydes and ketones using Tollens' reagent;
- **(vi)** acidic, neutral and basic compounds using indicators and sodium carbonate.

(d) An experiment to illustrate the use and interpretation of thin-layer or paper chromatography.

(e) The interpretation of IR, mass and NMR spectra (proton and carbon-13) (*Data Sheets will be allowed).*

F325 Equilibria, Energetics and Elements

(a) Rate experiments:

- **(i)** involving a measurement of an initial rate and the use of an appropriate graph to determine an order of reaction for a reagent;
- **(ii)** requiring continuous monitoring and the use of an appropriate graph to determine the rate of reaction and the order of reaction for a reagent.

(b) Candidates should be familiar with the procedures involved in an experiment to determine an equilibrium constant.

(c) Experiments to illustrate enthalpy changes of solution and neutralisation.

(d) Experiments to illustrate the use of electrode potentials to predict the likelihood of a reaction taking place. (e.g. simple test-tube experiments such as metal displacement reactions or simple redox processes).

(e) Test-tube experiments to illustrate:

(i) the precipitation of transition metal hydroxides;

(ii) ligand exchange reactions;

(iii) simple redox reactions such as the interconversion of the oxidation states of vanadium.

(f) Redox titrations involving the use of $MnO_4^-(aq)$ and $S_2O_3^{2-}(aq)$.

6 Apparatus list for Units F323 and F326

Unit F323

For each candidate, the following apparatus may be required to complete the assessed Tasks:

- Pipettes (10 cm^3 and 25 cm^3)
- Pipette fillers
- One burette (50 cm^3)
- One volumetric flask (250 cm^3,150 cm^3 or 100 cm^3)
- Two conical flasks (250 cm^3)
- One wash bottle
- Four measuring cylinders (250 cm^3, 100 cm^3, 50 cm^3 and 10 cm^3)
- Two filter funnels
- Evaporating basin (at least 30 cm^3)
- Beakers (400 cm^3, 250 cm^3 and 100 cm^3)
- Quickfit apparatus to carry out an organic preparation including distillation
- Plastic cup for use as a calorimeter
- Thermometer (–10 to +110 ^oC) or equivalent
- Stop clocks/watches reading to 1 s or better.
- Pipeclay triangle
- Porcelain crucible + lid
- Test-tubes and boiling tubes
- Test-tube holders
- Dropping pipettes
- Two stands and clamps
- Bunsen burner
- Balance reading to at least two decimal places
- Glass rods
- Heat proof mat
- Tripod and gauze

Unit F326

In addition to the apparatus indicated in Unit F323 above, the following may also be required.

- Melting point apparatus or oil bath/thiele tubes
- Apparatus for filtration under reduced pressure
- Melting point tubes

Alternative apparatus for candidates eligible for access arrangements

Advice about specialist equipment that may be suitable for candidates eligible for access arrangements (e.g. talking thermometers, talking scales, notched syringes) can be obtained from the RNIB (www.rnib.org.uk) and other specialist disability organisations. Before using such equipment for an assessed task the awarding body should be contacted to ensure that it does not interfere with the competence standards being assessed.

7 Resources

General resources

There are many resources available to help teachers provide support to candidates. These include both books and websites.

The OCR website – www.ocr.org.uk contains marked exemplar material from trials held in a number of centres.

Other useful websites are:

- the Royal Society of Chemistry at www.rsc.org
- the ASE at www.schoolscience.co.uk
- Chemguide at www.chemguide.co.uk
- www.practicalchemistry.org
- www.practicalchemistry.org/experiments/advanced/acid-base-reactions/topic-index.html
- www.creative-chemistry.org.uk/alevel/
- www.chemistry-videos.org.uk/chem%20clips/home.html
- www.avogadro.co.uk/chemist.htm
- www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/flashfiles/redoxNew/redox.html
- http://www.gettingpractical.org.uk/m3-3.php

INSET

INSET courses have been run in previous years offering guidance on marking. The course materials from these courses are available to download from www.cpdhub.ocr.org.uk. Search for course code BFSCALM.

Coursework consultancy

OCR offers a coursework consultancy service whereby centres can send up to four photocopies of marked work to OCR for commentary by a senior Moderator. If a centre wishes to make use of this service, work should be submitted to OCR no less than 8 weeks before the coursework submission date (15 May). The coursework enquiry form is available at www.ocr.org.uk and on Interchange.

8 Health & Safety

Useful information can be found at http://science.cleapss.org.uk

Candidates are expected to be familiar with one or both of the chemical hazard labelling systems illustrated below. Chemicals provided for assessment tasks should be labelled with the appropriate hazard symbol or pictogram and should take account of the labelling system that candidates will recognise *and* understand. Labels could also include additional information (e.g. "use a fume cupboard" or "avoid inhalation") if the risk assessment supported the view that this information would contribute to the safety of candidates carrying out the activity.

Oxidising

Toxic

Highly Flammable

Harmful or Irritant

Corrosive

'CHIP' system (being phased out)

Oxidising

Toxic

Highly Flammable

Indicates that the chemical could cause serious *long term* health effects.

Corrosive

Indicates less serious health hazards (e.g. skin irritants).

'CLP' system (being phased in)

CLP pictograms are also accompanied by a 'signal word' to indicate the severity of the hazard.

'DANGER' for more severe; 'WARNING 'for less severe.

In UK law, health and safety is the responsibility of the employer. Employees, i.e. teachers, lecturers, and technicians have a duty to cooperate with their employer on health and safety matters. Various regulations, but especially the COSHH Regulations 2002 and the Management of Health and Safety at Work Regulations 1999, require that before any activity involving a hazardous procedure or harmful micro-organisms is carried out, or hazardous chemicals are used or made, the employer must provide a risk assessment. A useful summary of the requirements for risk assessment in school or college science can be found at

http://www.ase.org.uk/resources/health-and-safety-resources

For members, the CLEAPSS® guide, *Managing Risk Assessment in Science** offers detailed advice. Most education employers have adopted a range of nationally available publications as the basis for their Model Risk Assessments. Those commonly used include:

• *Safety in Science Education*, DfEE, 1996, HMSO, ISBN 0 11 270915 X.

Now out of print but sections are available at

http://www.ase.org.uk/resources/health-and-safety-resources;

• *Topics in Safety*, 3rd edition, 2001, ASE ISBN 0 86357 316 9;

• *Safeguards in the School Laboratory*, 11th edition, 2006, ASE ISBN 978 0 86357 408 5;

• CLEAPSS® *Hazcards*, 2007 edition and later updates*;

• CLEAPSS® *Laboratory Handbook**;

• *Hazardous Chemicals*, A Manual for Science Education, 1997, SSERC Limited

ISBN 0 9531776 0 2.

Where an employer has adopted these or other publications as the basis of their model risk assessments, the teacher or lecturer responsible for overseeing the activity in the school or college then has to review them, to see if there is a need to modify or adapt them in some way to suit the particular conditions of the establishment.

Such adaptations might include a reduced scale of working, deciding that the fume cupboard provision is inadequate or the skills of the candidates are insufficient to attempt particular activities safely. The significant findings of such risk assessment should then be recorded, for example on schemes of work, published teachers' guides, work sheets, etc. There is no specific legal requirement that detailed risk assessment forms should be completed, although a few employers require this.

Where project work or individual investigations, sometimes linked to work-related activities, are included in specifications this may well lead to the use of novel procedures, chemicals or microorganisms, which are not covered by the employer's model risk assessments. The employer should have given guidance on how to proceed in such cases. Often, for members, it will involve contacting CLEAPSS® (or, in Scotland, SSERC).

*These, and other CLEAPSS® publications, are on the CLEAPSS website. Note that CLEAPSS® publications are only available to members. For more information about CLEAPSS - go to http://science.cleapss.org.uk. In Scotland, SSERC (www.sserc.org.uk) has a similar role to CLEAPSS®.

9 Interchange Help Sheet

Questions and answers

Where can I get the Practical Skills Assessment Tasks?
The live Tasks must be downloaded from Interchange, OCR's secure web portal. Printed copies will not be sent to Centres. Do not confuse the live assessment Tasks on Interchange with the Specimen Assessment Materials (SAMs) on the public OCR website – the SAMs must not be used for live assessment.

What is the web address for Interchange?
https://interchange.ocr.org.uk (Note: do not add 'www.' before the word 'interchange'.)

How do I obtain a username and password to log in to Interchange?
If your Centre is not already registered to use Interchange, your Examinations Officer will need to follow the information about how to register given in the Appendices of the GCE specifications and in the subject specific Practical Skills Handbook. Once registered, your Examinations Officer (or whoever holds the role of 'Centre Administrator') must either set you up as a new user with the role of 'Science Coordinator' to allow you to download the Tasks, or (less preferably) assign the role of 'Science Coordinator' to themselves so that they can download the Tasks and pass them to you.

How does my Examinations Officer set me up as a new user with the role of 'Science Coordinator'?
Your Examinations Officer (or whoever holds the role of 'Centre Administrator') should follow these steps in Interchange:

1. Hover the mouse cursor over 'Admin' in the left-hand menu, and then select 'Manage centre users' from the pop-up menu that appears. A list of all current users at your Centre will be loaded.

2. Click the 'Add New User' link (above the list of current users).

3. Enter user details.

4. Select the 'Roles' tab.

5. Select the role of 'Science Co-ordinator' on the left-hand side of the screen.

6. Click the '>' button. The 'Science Co-ordinator' role moves across to the right-hand side of the screen.

7. Click the 'User' tab.

8. Click 'Add'.

You will receive notification on screen of whether the new user was added successfully or not. Errors are indicated by a red asterisk (*) and are detailed on screen. *Please note that it usually takes approximately 20 minutes for the new user to be able to access Interchange.*

After logging in to Interchange, where can I find the Tasks?
Hover the mouse cursor over 'Coursework and tests' in the left-hand menu, and then select 'Science co-ordinator materials' from the pop-up menu that appears. Near the top of the new page that opens click the 'GCE AS/A2' link. Finally, select the appropriate specification name.

I don't have the 'Coursework and tests' and/or 'Science co-ordinator materials' options in the left-hand menu…
You need to be given the role of 'Science Co-ordinator'. Your Examinations Officer (or whoever holds the role of 'Centre Administrator') must assign the role of 'Science Co-ordinator' to you, as follows: step 1 above, click on the relevant username, steps 4 – 7 above, then click 'Update').

When I click on the specification name nothing happens / I get an error message / I get a warning about blocked content…
When you click on a subject heading (or click on the 'More detail…' link to the right of the heading), the rest of the page should slide down to reveal the Tasks and other materials available to download for the specification you selected. This works using Javascript, so your browser may alert you to 'active content' or 'blocked content'. Please ensure that you select the appropriate option to allow all content to run. In Internet Explorer, the alert may appear as a pale yellow bar at the top of the page; you will need to click on the pale yellow bar and select 'Allow blocked content'.

Check also that Javascript is enabled in your browser. In Internet Explorer, go to the 'Tools' menu and select 'Internet Options'; select the 'Advanced' tab on the far right; scroll down the list of check boxes to the coffee cup icon next to the heading 'Java (Sun)'; ensure that the 'Use Java for <applet>' check box (or similar) is ticked; click the 'OK' button; close Internet Explorer and then re-open it and log back in to Interchange. You should only ever have to do this once, unless you move to a different computer.

How do I download the Task 'zip' files?
Click on the Task that you want to download. If you are prompted whether to 'Open' or 'Save' the file, select 'Save'. You will be prompted for a location to which to save the file - select an appropriate location on your hard drive or USB stick. It is your responsibility to keep the Tasks strictly confidential after download, so choose a location that only you have access to. Remember that Tasks can only be used for assessment in the period stated on the Task cover (e.g. between 1 June 2009 and 14 May 2010). For future sessions, new Tasks need to be downloaded from Interchange.

What is a 'zip' file? / How to I get the Tasks from the 'zip' file?
The 'zip' file for each Task is a single file that has several PDF documents compressed inside it, namely the candidates' Task sheet and the Instructions for Teachers and Technicians together with any additional files pertinent to the Task. You will need to extract the compressed PDF files before you can use them.

In Windows XP and Windows Vista you can look inside the 'zip' file by double-clicking it, or by right-clicking it and selecting 'Explore'; once inside the 'zip', click on the 'File' menu, and then select 'Extract all'. If you use an older version of Windows (e.g. 95, 98, 2000, ME, or NT) you will need to download and use third-party 'zip' extractor software such as WinZip or PKZip to extract the files.

Mac OS X version 10.3 ('Panther') and later releases have built-in support for 'zip' files. If you are using an older release, or if you experience difficulty extracting the PDF documents from the 'zip' file, try downloading and using third-party 'zip' extractor software such as StuffIt Expander to extract the files.

I get an error message saying that the 'zip' file is corrupt…
OCR has tested the files to ensure that they can all be downloaded successfully. If you are having problems with one of the files you have downloaded, delete the file and download it again or try downloading it on a different computer. Also check with your IT administrator to ensure that a virus scanner or firewall on your Centre's network is not disrupting the file.

Some of the Tasks / Mark Schemes are missing…
Tasks for all GCE science specifications will be uploaded from 1st June each year. The previous year's Tasks will have been taken down during May, and must not be used for assessment in the current session. If all of the Tasks are not available the first time you log in, check back in subsequent weeks for the latest additions, or register for e-mail updates to be alerted when new Tasks are uploaded (see below). Mark Schemes for all of the Tasks will be uploaded from 1st December each year.

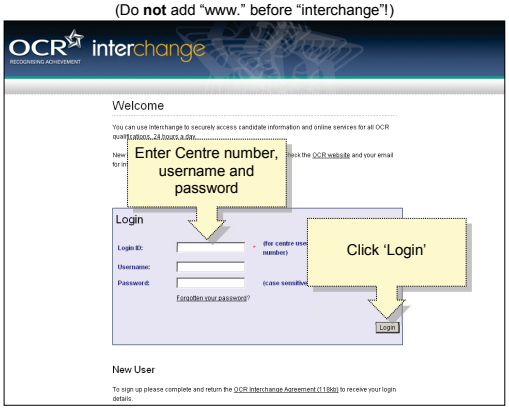
Do I have to keep logging in to Interchange to check for updates?
No. Just above the Tasks for each specification is a notice about 'e-mail updates'. To be notified by e-mail when changes are made to the Task pages, send an e-mail to GCEsciencetasks@ocr.org.uk including your name, Centre number and Centre name, and state the name of the specification(s) for which you wish to receive updates in the subject line.

Is there a way to see titles/summaries the Tasks without downloading them all?
The document called 'Getting Started' in the 'Support Materials' box on each specification page gives titles and summaries for all Tasks that are available for assessment in the current session. Click the 'Getting Started' link to download the document.

1

https://interchange.ocr.org.uk

(Do **not** add "www." before "interchange"!)



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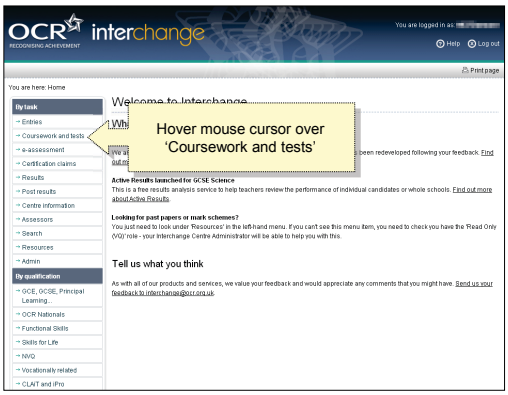

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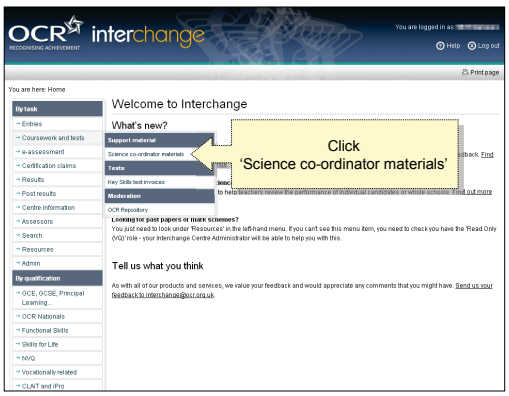

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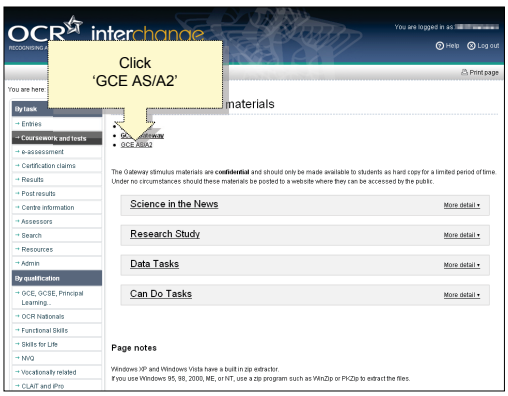

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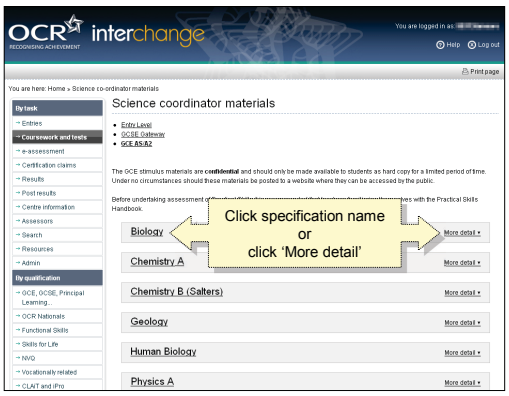

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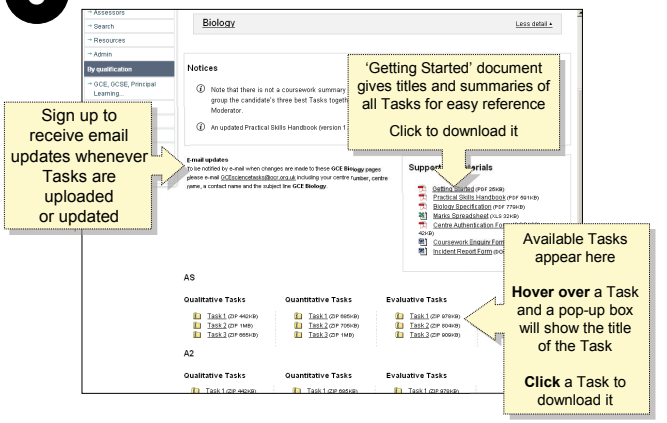


10 Helpful Guide on Practical Skills

This guide is designed to provide helpful tips on the qualitative, quantitative and evaluative tasks for the AS and A2 Practical Skills. It is envisaged that the guide will promote a better understanding of what examiners expect from the candidates. There is particular focus on useful terms, measurements, graphical work and uncertainties in results.

Useful terms

Accuracy is a measure of the closeness of agreement between an individual test result and the accepted reference value. If a test result is **accurate**, it is in close agreement with the accepted reference value.

Error (of measurement) is the difference between an individual measurement and the **true** value (or accepted reference value) of the quantity being measured.

Precision is the closeness of agreement between independent measurements obtained under the same conditions. It depends only on the distribution of random errors (*i.e.* the spread of measurements) and does not relate to the true value. A measurement is 'precise' if values cluster closely.

Uncertainty is an estimate attached to a measurement which characterises the range of values within which the true value is asserted to lie. This is normally expressed as a range of values such as 44.0 ± 0.4.

Repeatability in quality when repetition under the same conditions gives the same or similar results e.g. when comparing results from the same pupil or group, using the same method and equipment.

Reproducibility is precision obtained when measurement results are produced by different laboratories (and therefore by different operators using different pieces of equipment). A measurement is 'reproducible' in quality when reproducing under equivalent (but not identical) conditions gives the same or similar results e.g. when comparing results from different pupil groups, methods or equipment – a harder test of the quality of data.

All of these definitions are taken from *Language of scientific measurements and investigations. The Language of Measurement, Terminology used in school science investigations. The Association for Science Education. ASE Publications, 2010.*

Measurements

1. How accurate are measurements?

When using a digital measuring device (such as a modern top pan balance or ammeter),

- record *all* the digits shown.

When using a non-digital device (such as a ruler or a burette),

- record all the figures that are known for certain plus one that is estimated.

As a general rule, the uncertainty is often taken to be half a division on either side of the smallest unit on the scale you are using. However, the accuracy of measurements does also depend on the quality of the apparatus used, such as a balance, thermometer or glassware.
For example, a 100 cm^3 measuring cylinder is graduated in divisions every 1 cm^3.

- A Class A measuring cylinder has a maximum error of half a division or 0.5 cm^3
- A Class B measuring cylinder has a maximum error of a whole division or 1 cm^3.

Because of this variability, assessed Tasks will state the **maximum error** in any measurement that is being made.

2. Examples of maximum errors

When glassware is manufactured there will always be a maximum error. This is usually marked on the glassware.

Some examples are shown below. Note that the actual maximum error on a particular item of glassware may differ from the values given below.

Volumetric or standard flask (Class B)

- A 250 cm^3 volumetric flask has a maximum error of 0.2 cm^3 or 0.08%.

Pipette (Class B)

- A 25 cm^3 pipette has a maximum error of 0.06 cm^3 or 0.24%.

Burette (Class B)

- A pipette has a maximum error of 0.05 cm^3 in each measurement.

Some examples

The significance of the maximum error in a measurement depends upon how large a quantity is being measured. It is useful to quantify this error as a percentage error.

$$\text{Percentage error} = \frac{\text{maximum error}}{\text{quantity measured}} \times 100\%$$

For example, a two-decimal place balance may have a maximum error of 0.005 g.
For a mass measurement of 2.56 g,

- percentage error = $\frac{0.005}{2.56} \times 100\% = 0.20\%$

- For a mass measurement of 0.12 g, the percentage error is much greater:

  Percentage error = $\frac{0.005}{0.12} \times 100\% = 4.2\%$

3. Multiple measurements

For multiple measurements using the same two-decimal place balance, there will be a maximum error of 0.005 g for each measurement.
For two mass measurements that give a resultant mass by difference, there are two maximum errors:

$$\text{Percentage error} = \frac{2 \times \text{maximum error in each measurment}}{\text{quantity measured}} \times 100\%$$

For example, using the same two-decimal place balance,

Mass of crucible + crystals before heat = 23.45 g	maximum error = 0.005 g
Mass of crucible + crystals after heat = 23.21 g	maximum error = 0.005 g
Mass lost = 0.23 g	maximum overall error = 2 x 0.005 g

There is a negligible percentage error in each mass measurement but the overall error in mass loss is much greater:

$$\text{Percentage error in mass loss} = \frac{2 \times 0.005}{0.23} \times 100\% = 4.3\%$$

4. Reading burettes

A burette is graduated in divisions every 0.1 cm^3.
A burette is a non-digital device, so we record all figures that are known for certain plus one that is estimated.
Using the half-division rule, the estimation is one of 0.05 cm^3. We therefore record burette measurements to two decimal places with the last figure either '0' or '5'.
The maximum error in each measurement = 0.05 cm^3.
The overall maximum error in any volume measured always comes from two measurements, so the overall maximum error = 2 x 0.05 cm^3 = 0.1 cm^3.
In a titration, a burette will typically deliver about 25 cm^3 so the percentage error is small.

- Percentage error = $\frac{2 \times 0.05}{25.00} \times 100\% = 0.4\%$

For small volumes, the percentage error becomes more significant
For delivery of 2.50 cm^3,

- percentage error = $\frac{2 \times 0.05}{2.50} \times 100\% = 4\%$

5. Recording volumes during titrations

As shown above, each burette measurements should be recorded to two decimal places with the last figure either '0' or '5'.

During a titration, it is expected that students will record both initial and final burette readings from which a titre is calculated by difference. It is usual practice to record titration results in a table of the type shown below.

	Trial	**1**	**2**	**3**
Final burette reading / cm^3				
Initial burette reading / cm^3				
Titre / cm^3				
Mean titre to one decimal place / cm^3				

When recording the titre, it is normal practice to use two decimal places. This is what will be expected within the assessment Tasks.

6. Mean titres

For the purposes of assessment, candidates are asked to provide their mean titre to one decimal place.

7. How many significant figures should be used?

The result of a calculation that involves measured quantities cannot be more certain than the *least* certain of the information that is used. So the result should contain the same number of significant figures as the measurement that has the *smallest* number of significant figures.

A common mistake by students is to simply copy down the final answer from the display of a calculator. This often has far more significant figures than the measurements justify.

8. Rounding off

When rounding off a number that has more significant figures than are justified (as in the example above), if the last figure is between 5 and 9 inclusive round up; if it is between 0 and 4 inclusive round down.

For example, the number 350.99 rounded to:

4 sig fig is 351.0
3 sig fig is 351
2 sig fig is 350
1 sig fig is 400

Notice that when rounding you only look at the one figure beyond the number of figures to which you are rounding, *i.e.* to round to three sig fig you only look at the fourth figure.

9. How do we know the number of significant figures?

In the example above, 351 has been rounded to the 2 sig fig value of 350.
However, if seen in isolation, it would be impossible to know whether the final zero in 350 is significant (and the value to 3 sig figs) or insignificant (and the value to 2 sig figs).
In such cases, standard form should be used and is unambiguous:

- 3.5×10^2 is to 2 sig figs
- 3.50×10^2 is to 3 sig figs

10. When to round off

It is important to be careful when rounding off in a calculation with two or more steps.

- Rounding off should be left until the very end of the calculation.
- Rounding off after each step, and using this rounded figure as the starting figure for the next step, is likely to make a difference to the final answer. This introduces a **rounding error**.

Students often introduce rounding errors in multi-step calculations.

Example
When 6.074 g of a carbonate is reacted with 50.0 cm^3 of 2.0 mol dm^{-3} HC*l*(aq) (which is an excess), a temperature rise of 5.5 °C is obtained. The specific heat capacity of the solution is 4.18 J g^{-1} K^{-1},
The heat produced = 50.0 × 4.18 × 5.5 for which a calculator gives 1149.5 J = 1.1495 kJ

> *Since the least certain measurement (the temperature rise) is only to 2 significant figures the answer should also be quoted to 2 significant figures.*

Therefore, the heat produced = 1.1 kJ

- *It should be noted however, that if this figure is to be used subsequently to calculate the enthalpy change per mole then the rounding off should **not** be applied until the final answer has been obtained.*

For example, if the carbonate has a molar mass of 84.3 g mol^{-1}, the enthalpy change per mole of carbonate can be calculated from the value above.

Using the calculator value of 1.1495 kJ for the heat produced,

- enthalpy per mole = 15.95371255 kJ mol^{-1}.
- rounding to 2 sig figs gives 16 kJ mol^{-1}

Using the rounded value of 1.1 kJ for the heat produced,

- enthalpy per mole = 15.26671057 kJ mol^{-1}.
- rounding to 2 sig figs gives 15 kJ mol^{-1} and we have a 'rounding error'.

11. Errors in procedure

The accuracy of a final result also depends on the procedure used. For example, in an enthalpy experiment, the measurement of a temperature change may be precise but there may be large heat losses to the surroundings which affect the accuracy of overall result.

12. Anomalous readings

Where an experiment uses repeated measurements of the same quantity, such as repeated titration readings, anomalous readings should be identified. If a titre is clearly outside the range of all other readings, it can be judged as being anomalous and should be ignored when the mean titre is calculated.

Similarly, if a plotted graph reveals that a value is anomalous, then it should be ignored.

References

The Royal Society of Chemistry has produced several very helpful documents on measurements and errors, see:

www.rsc.org/education/teachers/learnnet/pdf/learnnet/RSCmeasurements_teacher.pdf

www.rsc.org/pdf/amc/brief13.pdf

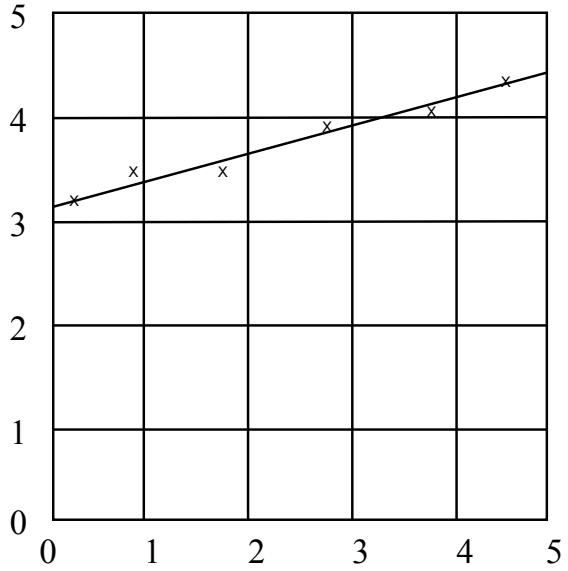
Graphical work

Credit for graphical work usually may often fall into five categories:

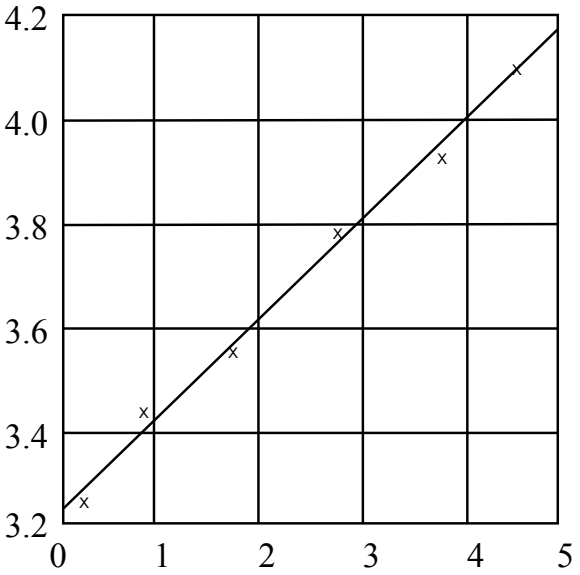
- Choice of scale
- Plotting of points
- Line of best fit
- Calculation of gradient
- Determination of the *y*-intercept

1. Choice of scales

a. Scales should be chosen so that the plotted points occupy at least half the graph grid in both the *x* and *y* directions.



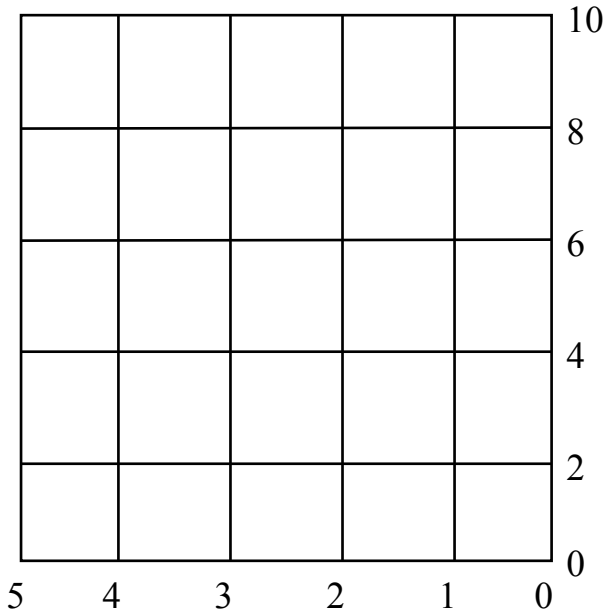
Not acceptable - scale in the *y*-direction is compressed



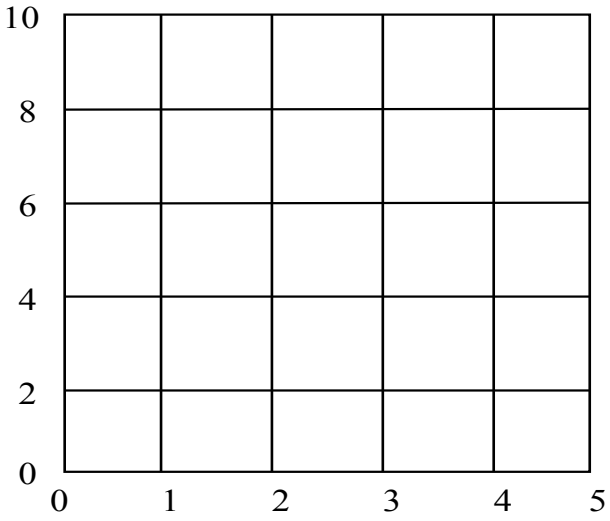
Acceptable - points fill more than half the graph grid in both the *x* and *y* directions

b. It is expected that each axis will be labelled with the quantity which is being plotted.

c. The scale direction must be conventional (i.e. increasing from left to right).



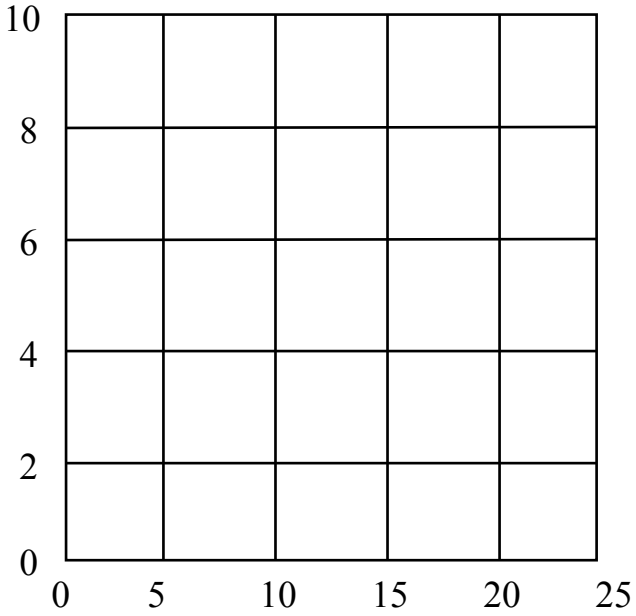
Not acceptable - unconventional scale direction



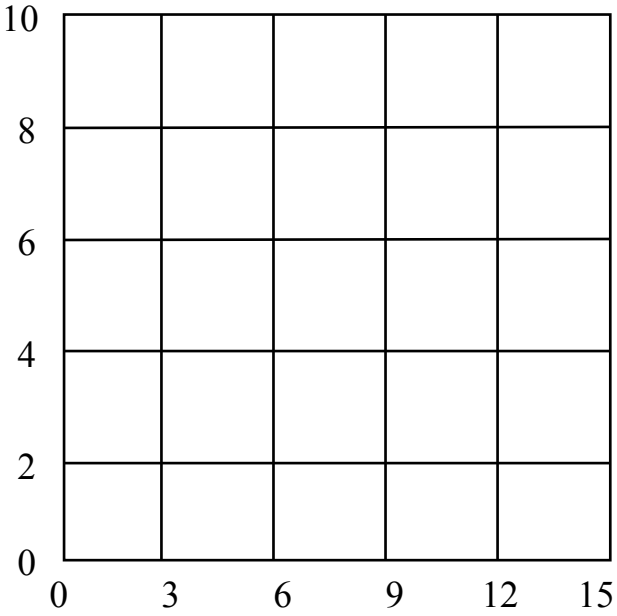
Acceptable - conventional scale direction

This problem often occurs when scales are used with negative numbers.

d. Candidates should be encouraged to choose scales that are easy to work with.



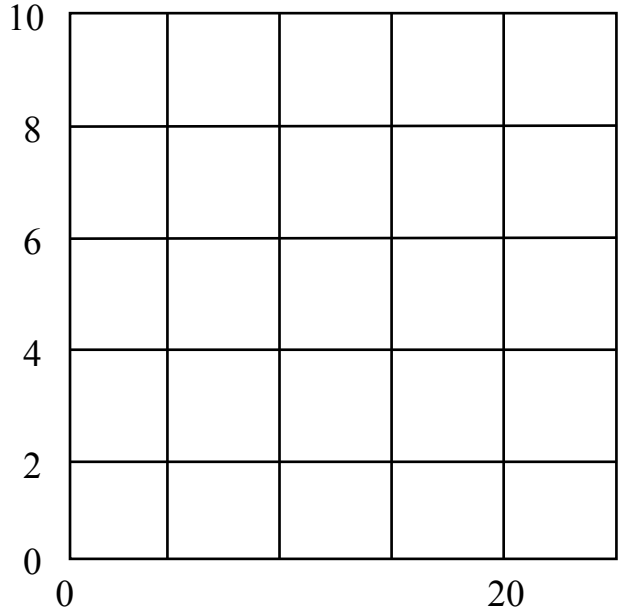
Acceptable scale divisions.



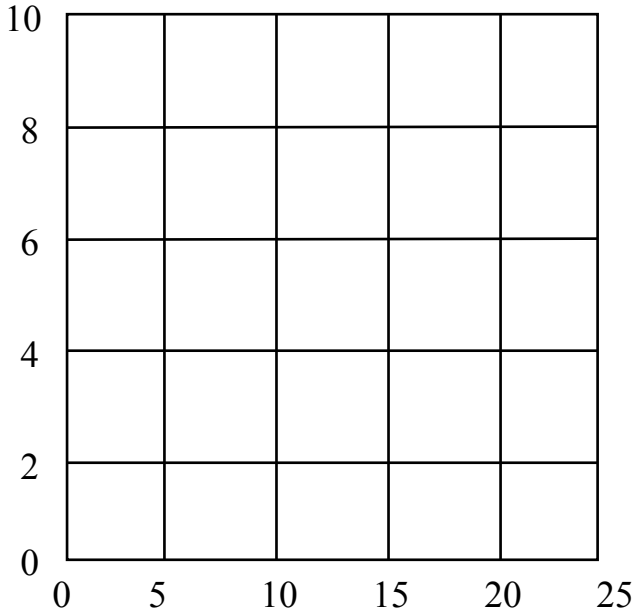
Not acceptable - awkward scale on the *x*-axis.

Candidates who choose awkward scales often lose marks for plotting points (as they cannot read the scales correctly) and calculation of gradient (Δx and Δy often misread - again because of poor choice of scale).

e. Scales should be labelled reasonably frequently (i.e. there should not be more than three large squares between each scale label on either axis).

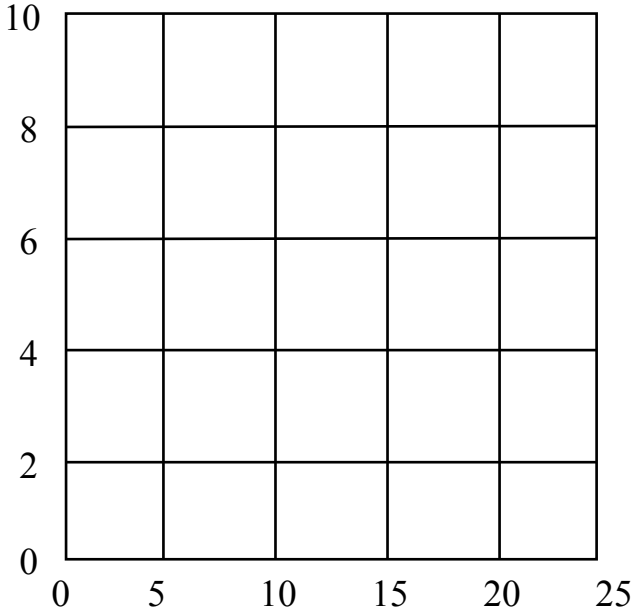


Not acceptable - too many large squares with no label

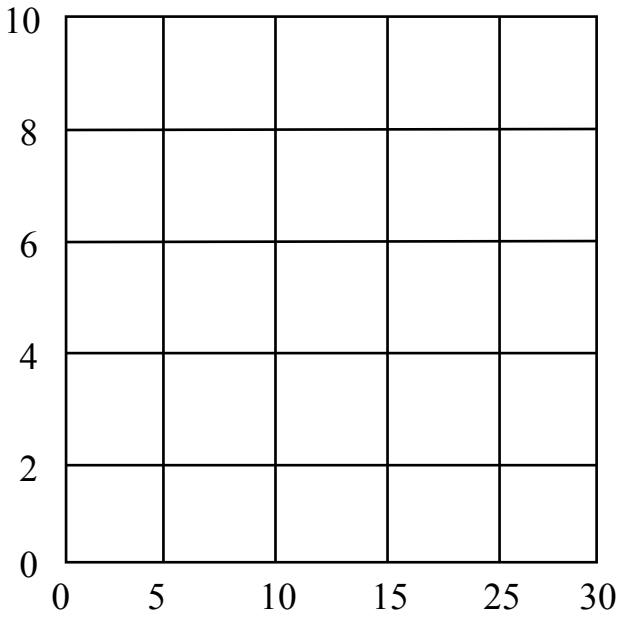


Acceptable - scales have regular labels

f. There should be no 'holes' in the scale.



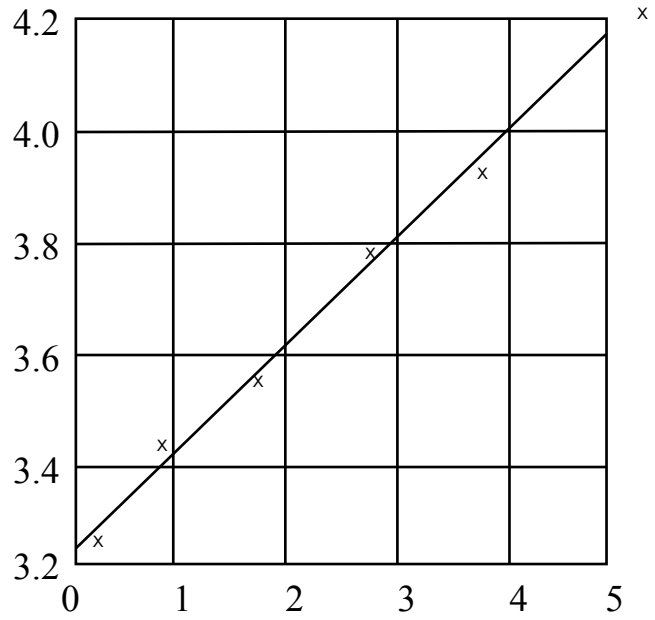
Acceptable - scale labelling is regular



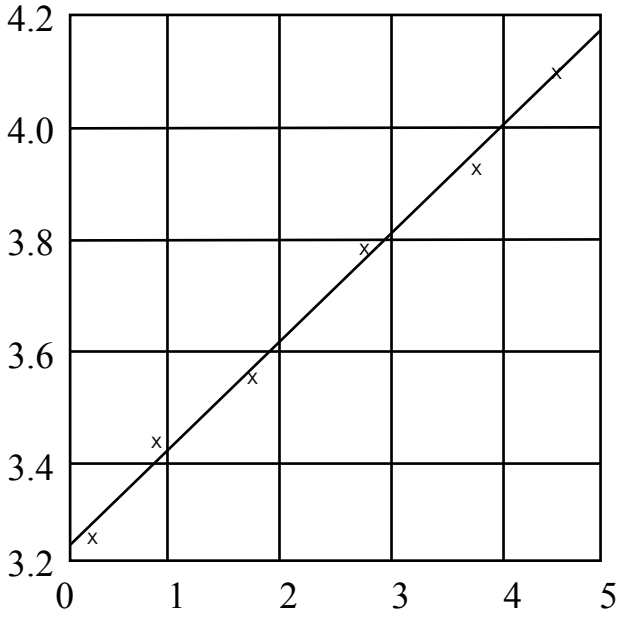
Not acceptable - non-linear scale on the *x*-axis

2. Plotting of points

a. Plots in the margin area are not allowed. Candidates would find it helpful to be told that any plots in the margin area will be ignored. Sometimes weaker candidates (realising they have made a poor choice of scale) will attempt to draw a series of lines in the margin area so that they can plot the 'extra' point in the margin area. This is considered to be *bad practice* and will not be credited.



Not acceptable - the last point has been plotted in the margin area



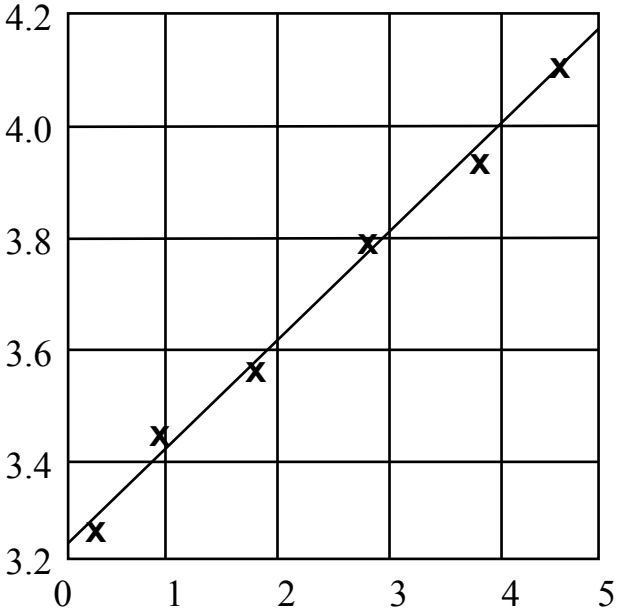
Acceptable - all plotted points are on the graph grid

b. It is expected that all observations will be plotted (e.g. if six observations have been made then it is expected that there will be six plots).

c. Plotted points must be accurate to half a small square.

d. Plots must be clear (and not obscured by the line of best fit or other working).

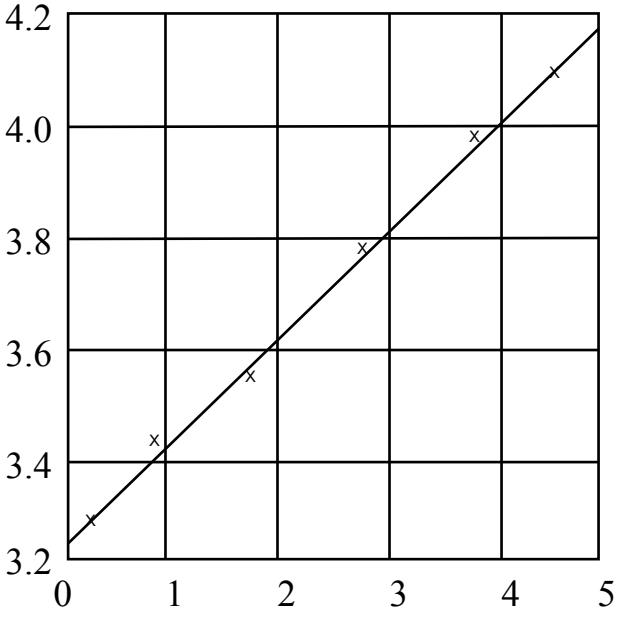
e. Thick plots are not acceptable. If it cannot be judged whether a plot is accurate to half a small square (because the plot is too thick) then the plotting mark will not be awarded.



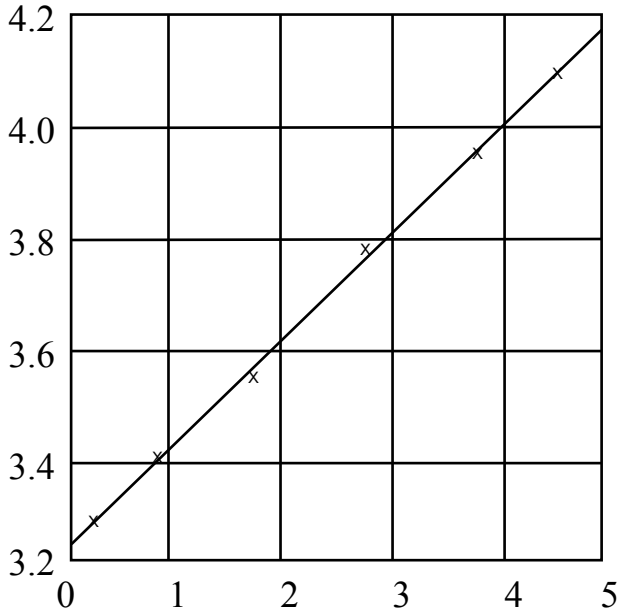
Thick plots not acceptable

3. Line (or curve) of best fit

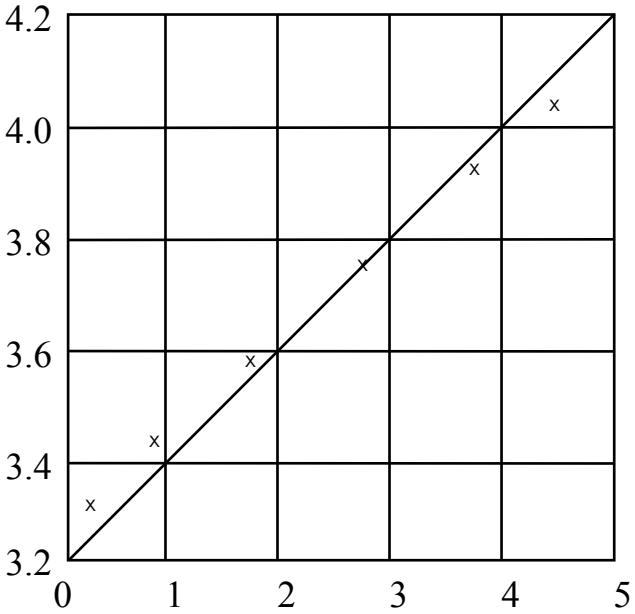
a. There must be a reasonable balance of points about the line. It is often felt that candidates would do better if they were able to use a clear plastic rule so that points can be seen which are on <u>both</u> sides of the line as it is being drawn.



Not acceptable - too many points above the line

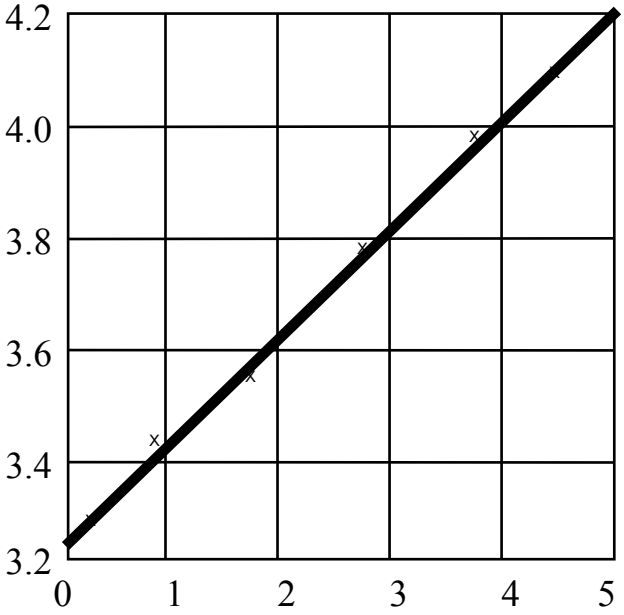


Acceptable balance of points about the line

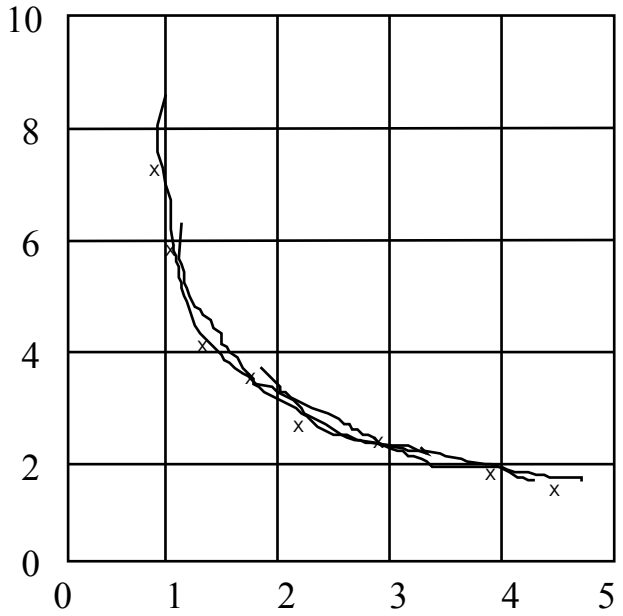


Not acceptable - forced line through the origin

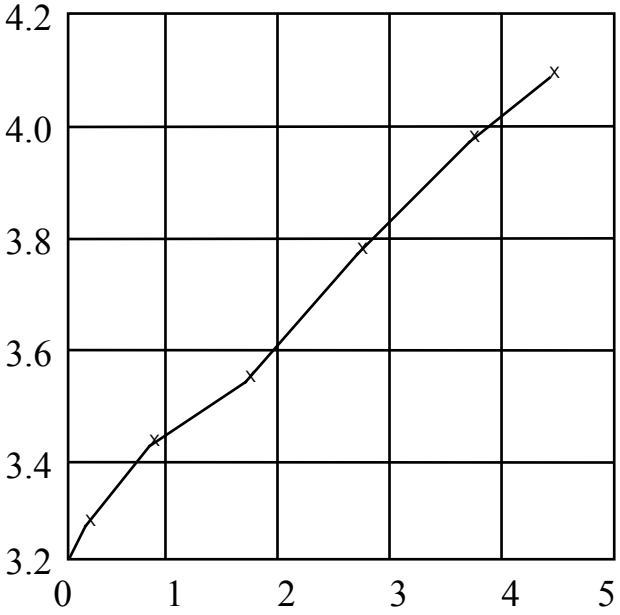
b. The line must be thin and clear. Thick/hairy/point-to-point/kinked lines are not credited.



Not acceptable - thick line



Not acceptable - 'hairy' curve

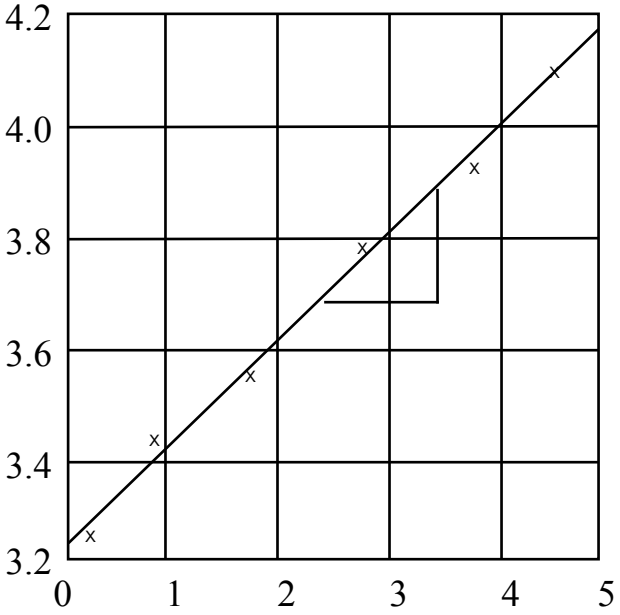


Not acceptable – joining point-to-point

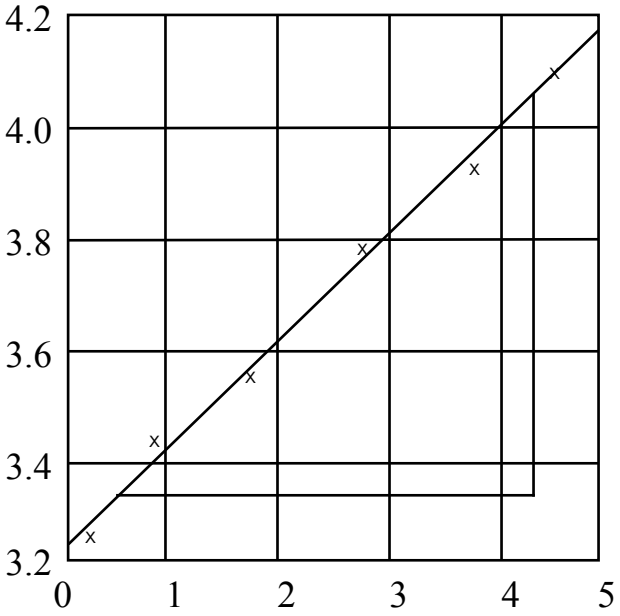
3. Determining gradients

a. All the working must be shown. A 'bald' value for the gradient may not be credited. It is helpful to both candidates and examiners if the triangle used to find the gradient were to be drawn on the graph grid and the co-ordinates of the vertices clearly labelled.

b. The length of the hypotenuse of the triangle should be greater than half the length of the line which has been drawn.



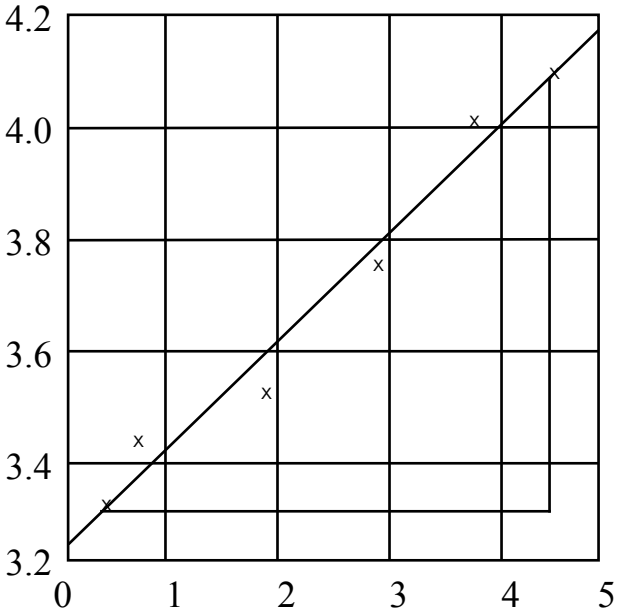
Not acceptable - the ‘triangle’ used is too small



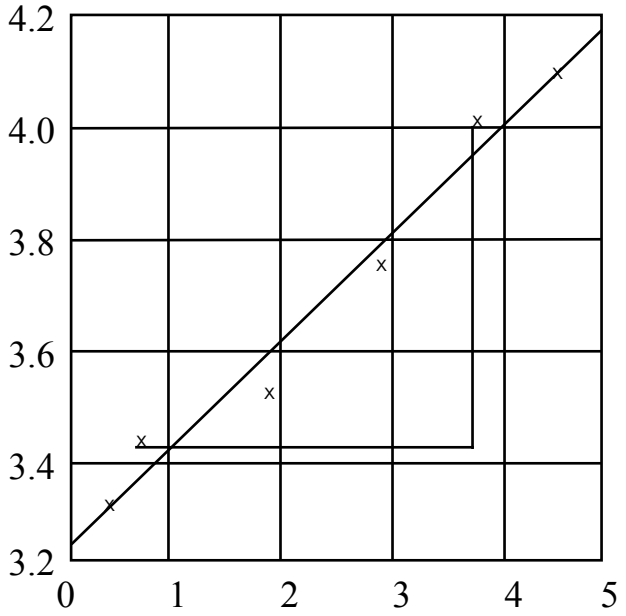
Acceptable – a large 'triangle' used

c. The value of Δx and Δy must be given to an accuracy of at least one small square (i.e. the 'read-off' values must be accurate to half a small square).

d. If plots are used which have been taken from the table of results then they must lie on the line of best fit (to within half a small square).



Acceptable - plots on line

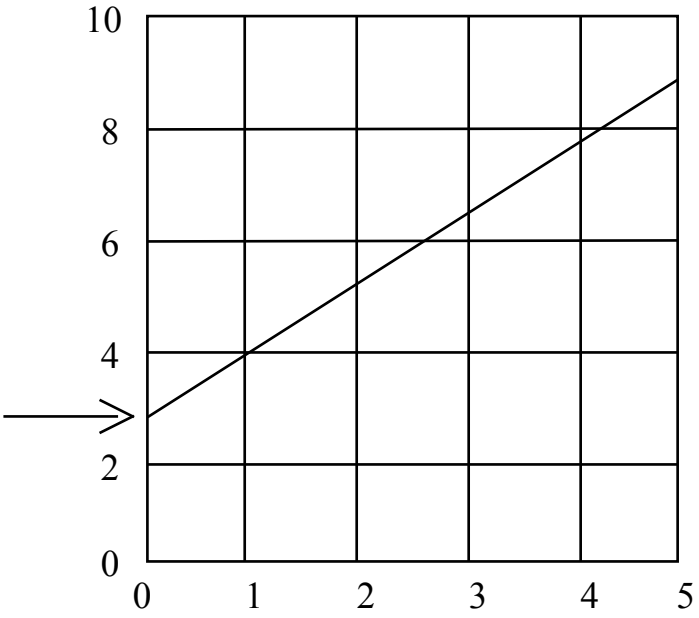


Not acceptable - the data points used which do not lie on the line of best fit

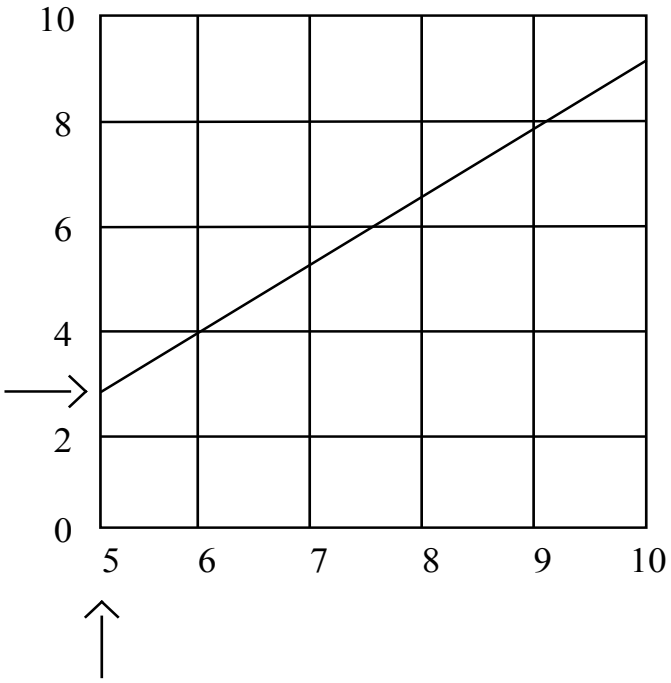
e. A gradient value has no unit since it is a ratio of two numbers from the graph

5. Intercept

a. The *y*-intercept must be read from an axis where $x = 0$. It is often the case that candidates will choose scales so that the plotted points fill the graph grid (as they should do) but then go on to read the *y*-intercept from a line other than $x = 0$.



Acceptable – the value taken from the line $x = 0$



Not acceptable – the *y*-intercept is found from the line *x* = 5

b. It is expected that candidates will be able to use the equation of a straight line ($y = mx + c$) to determine the *y*-intercept if the choice of scale is such that it is not possible to take a direct reading from the *y*-axis when *x* = 0. In this case it is expected that a pair of *x* and *y* values from the line of best fit (together with a gradient value) will be substituted into the equation *y* = *mx* + *c* to give a value for the *y*-intercept.

Uncertainties

1. Percentage uncertainty

In the evaluative tasks candidates may be asked to calculate a simple percentage uncertainty or state the uncertainty in a measurement. When repeated readings have been done then it is expected that the uncertainty in the measured quantity will be half the range. The expression

$$\text{percentage uncertainty} = \frac{\text{uncertainty}}{\text{average value}} \times 100\%$$

should be used.

If *single* readings have been taken then the uncertainty should be the smallest interval or division on the measuring instrument. Consider the example below.

Example: A metre rule is used to measure the length of a book.

uncertainty in the measuring instrument (the ruler) = ± 1 mm

length = (295 $\pm$ 1) mm

The percentage uncertainty in the length is

$$\% \text{ uncertainty} = \pm \frac{1}{295} \times 100 = \pm 0.34\%$$

Determining the uncertainty in time measurements using a stopwatch raises a few issues. Almost all stopwatches will give times to one hundredth of a second, but candidates clearly cannot operate

the watch to this accuracy. Human reaction time will give errors of (typically) 0.1 s to 0.6 s, which are reasonable estimates of the uncertainty.

Similar ideas apply to measurement of length, where parallax errors may make it difficult for candidates to measure a length to the accuracy of the rule used.

2. The rules for determining percentage uncertainties

A key assessment objective of the evaluative tasks is going to be determining the final uncertainty in a quantity. Here are some useful rules:

- If $y = ab$

  Rule: % uncertainty in *y* = % uncertainty in *a* + % uncertainty in *b*

- $y = \frac{a}{b}$ (For example when determining the gradient of a line)

  Rule: % uncertainty in *y* = % uncertainty in *a* + % uncertainty in *b*

- $y = a^2$

  Rule: % uncertainty in *y* = 2 × % uncertainty in *a*

3. Determining the uncertainty in the gradient using maximum and minimum gradients

Candidates may determine the uncertainty in the gradient by drawing lines of maximum and minimum gradients through their scattered data points. What happens when there is little scatter of the data points? This is when candidates may draw *error bars*.

The uncertainty in the gradient can be determined as follows:

a. Error bars may be added to each plotted point if the data points are not too scattered.

b. Draw a best fit line through the scattered points (or through the error bars). The worst acceptable line is then drawn. This will either be the *steepest* or *shallowest* line.

c Determine the gradient of the best fit line and the gradient of the worst acceptable line.

d Uncertainty = |gradient of best fit line – gradient of worst acceptable line|.

e The percentage uncertainty in the gradient can be determined as follows:

$$\text{percentage uncertainty} = \frac{\text{uncertainty}}{\text{gradient of best fit line}} \times 100\%$$

4. Determining the uncertainty in the *y*-intercept using maximum and minimum gradients

Candidates may determine the uncertainty in the *y*-intercept by using lines of maximum and/or minimum gradients through their scattered data points. What happens when there is little scatter of the data points? This is again when candidates may draw *error bars*.

a. Error bars may be added to each plotted point if the data points are not too scattered.

b. Draw a best fit line through the scattered points (or through the error bars). The worst acceptable line is then drawn. This will either be the *steepest* or *shallowest* line.

c Determine the *y*-intercept of the worst acceptable line and the *y*-intercept of the best fit line.

d Uncertainty = |*y*-intercept of best fit line – *y*-intercept of worst acceptable line|.

e The percentage uncertainty in the *y*-intercept can be determined as follows:

$$\text{percentage uncertainty} = \frac{\text{uncertainty}}{y\text{ - intercept}} \times 100\% .$$